Developing A Web-Enabled Air Quality Monitor

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Abstract

Building on established efforts to publicly monitor radiation, Safecast is developing a set of web-enabled atmospheric monitors which, using a variety of gas sensors, will be able to to quantitavely monitor air quality for mapping and analysis. Our efforts involved the construction of a prototype to log concentrations of particulate matter and LPG along with GPS coordinates. Sensors are calibrated with on-board air temperature and humidity. Our prototype allows for further development and deployment, via a modular design, to add on additional sensors for continual community-based monitoring.

Background

There are a number of metrics used to determine air quality. For this prototype just two, particulate matter and LP gas concentration, were used.

Figure 1: Visual evidence of particulate matter in Beijing

Figure 2: A dramatic display of natural gas produced by hydraulic fracturing

For these sensors propane concentration is recorded in parts per million and particulate matter is recorded as the number of particulates with a diameter over one micron occupying a cubic meter of air. For particulates this standard is referred to as PM1.0 Both propane gas and particulate matter are common air pollutants, and fine-grained particulates were included in the prototype design as they can cause long-term lung damage even if they're not as visible as coarser-grained soot.

Hardware - Overview

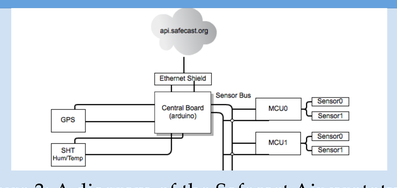

Figure 3: A diagram of the Safecast Air prototype.

Hardware - Detail

The current prototype (Fig. 3) consists of a central processing (CP) board which is directly connected to a temperature and humidity sensor, GPS receiver, an Ethernet connection, and an I²C bus with a gas sensor module. The gas sensor module consists of a microcontroller unit (MCU) and a resistive natural gas sensor. This design allows for temperature and humidity data to be pushed to the MCU's over the I²C bus and gas sensor data pulled the MCU's back. Gas concentration with a specific GPS stamp is posted to an online database. The central processing board is capable of detecting new modules on start up.

Software

The Software written for this prototype can be broken down into the following components:

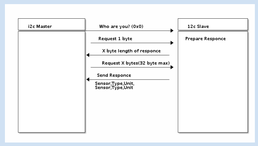

Figure 4: The basic command and data flow

The CP:
1. Pushes and Pulls data from MCUs at a byte level.
2. Identifies connected MCUs and attached sensors.
3. Collects and distributes temperature and humidity data.
4. Collects and sends Sensor and GPS data to Safecast API.

The MCU currently listens for commands from the CP:

Command	Returned value
0x01	Sensor0 info
0x02	Sensor 1 info
0x03	Sensor0 value
0x04	Sensor1 value
0x10	Temperature data from CP
0x11	Humidity data from CP

After a 1-2 byte header ASCII data is sent/received

Calibration Efforts

With resistive gas sensors a standard calibration requires the the Use of concurrent temperature and humidity data. Using manufacturer specifications, and the Plot Digitzer program, a best-fit function was fit to provided calibration curves.

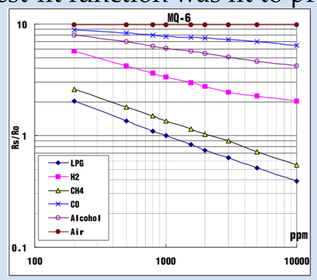

Figure 5 – Sensor resistance versus natural gas concentration

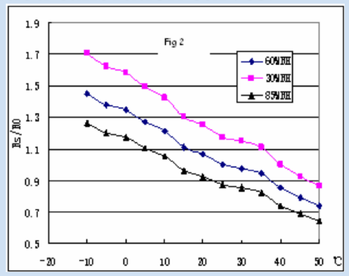

Figure 6 – Sensor resistance versus temperature at three levels of humidity

Future Directions

The Safecast air monitor is being developed to be a modular system such that additional gas sensor modules, or even different classes of sensors, could be readily added onto the platform for continuous distributed monitoring. This would allow for low-cost and widespread monitoring of a variety of environmental metrics in near real time.

Acknowledgements

Special thanks goes to the Safecast team and Cal Poly SLO for their technical and material support.

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